Cost-benefit analysis at the floodgates: Governing democratic futures through the reassembling of Iran's Waterways

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Abstract

A burgeoning scholarship has taken seriously the use and management of the world's freshwater as a site of critical investigation while highlighting the contribution of science and technology studies in making the infrastructural life of water visible. However, studies say little about the calculative terms of the decision-making process involved in infrastructural appraisal and are often taken for granted as something inevitable. This article examines the unexpected and remarkable role that cost-benefit analysis played in governing Iran's democratic future through the assembling of a dam in the mid-twentieth century. Indeed, cost-benefit analysis traveled the world by flows of water. I investigate the ways in which the calculation of risk generated by the device of cost-benefit analysis of neoclassical economics became over several decades the most influential language for explaining and organizing the relationship between humans and nature in southwest Iran. The waters of the Dez River and other major rivers of the world shaped the building of large-scale infrastructural projects around dams, but they were simultaneously entangled with the production of economic information about the costs and benefits to the local, making possible the development of new methods of governing democracies in terms of risk. US-based government aid agencies, institutions of global economic governance, private American investors, engineers, and agricultural scientists converged in a small corner of Iran to transform the region, its water, and its farmers into a laboratory of grass-roots democracy for a profit.

Keywords: water, infrastructure, democracy, Iran, cost-benefit analysis, risk

> It should be remembered that [Iran's] essential economy can be summed up in one word "water"
> NS Roberts, Board of Trade, 1 May 1946, FO 371/52763.

On the heels of the Anglo-American engineered overthrow of Iran's reformist nationalist government in August 1953, the national newspaper, *Etela'at*, first advertised the government's 'extensive plans' for the economic transformation of Khuzestan province in southwest Iran along the Persian Gulf.[1] According to the provincial governor, the development of the agricultural and industrial sectors would address the worsening crisis of unemployment in the region, specifically through the construction of dams. Khuzestan province was known for being home to the largest oil refinery in the world and the major oil producing fields of the Middle East. However, US

government development experts based in Iran argued that water not oil was 'liquid gold' to the Middle East, and Khuzestan embodied major opportunities for irrigation, flood control, and increased food production such as sugar.[2] In subsequent years, national newspapers advertised 'a politics of material promise' exemplified by the flourishing future of Khuzestan province as a model for the world and the primary source of foodstuffs for the nation (Schayegh, 2012: 627). This politics was embodied in the technical structure of the Dez Dam, a 'high-arch dam' planned to reach a height of over 200 meters with a reservoir capacity of 3,350 million cubic meters and the potential to produce 520,000 kilowatts of electricity, along with drinking water (Figure 1).[3]

Commenced in 1959, the Dez Dam was renamed the Mohammed Reza Shah Pahlevi Dam on the occasion of the ruling monarch's visit to the site at its inauguration in March 1963. Built on the Dez River, a tributary of one of the largest rivers in the Middle East (Karun River), it was the first of fourteen multi-purpose dams planned for diverting and controlling the five major waterways of the region (Lilienthal, 1959b: 135). The dam was based on the Tennessee Valley Authority's (TVA) 1930s model of integrated river basin development for revitalizing the depressed areas of the American South (Clapp, 1957: 9). Starting in the 1940s, the development of the Khuzestan river basins formed part of massive projects for transforming nature to support Cold War strategies of combatting the spread of Communism in the Middle East through river basin development programs centered on high dams (Tucker, 2010: 139). American political strategists relied on the Cold War framing to consolidate a new order of growing US hegemony, the collapse of empire, and the institutionalization of economic expertise at agencies such as the World Bank through the publication of statistics and the proliferation of political programmes defining as their object separate economies in a global political order of nation-states (Mitchell, 2011b: 138). The policy was shaped by American development economists such as W.W.

Rostow who espoused modernization theory as a means of bringing political stability to the Middle East (Popp, 2008). Thus, the technical structure of the dam embodied the possibility for democratic forms of politics through the pursuit of 'economic growth' and top-down economic planning among an elite group of technocrats. Advertised as '[a] technical tool for social change' in the Middle East (White, 1957: 157), large-scale dams were a way to manage not just irrigation and power systems, but relations between the Global North and new states in the Global South, through economic development agreements with foreign firms (Lilienthal, 1959b: 134).

The problem was that United Nations Food and Agricultural Organization (FAO) representatives were 'doubtful if anything could ever be accomplished in Khuzestan owing to the salinity of the soil and water and the unbearable climate.'[4] The FAO was an initiator of regional meetings on irrigation practices in the Middle East, one of the first of which was held in Tehran, Iran in 1954.[5] A 1958 World Bank study confirmed that salinity problems were a serious impediment to agricultural productivity in Iran. In the arid Khuzistan plains, the problem had existed 'since ancient times.'[6] Making matters worse, Iran's Independent Irrigation Agency, established with FAO assistance in 1943, had failed to address the lack of regulations for water rights, water payments, and the settlement of land ownership problems, which either delayed or halted many of the large irrigation projects in Khuzestan and elsewhere.[7] World Bank experts complained that Iranian authorities did not see the importance of getting decisions agreed upon with landowners and cultivators before commencing dam construction works. Considerable doubts were reflected in the World Bank's appraisal of the economic justification for a sugar cane industry and power generation, which would be based on hydro-electric power instead of the cheaper, thermal power, which Bank experts preferred.[8] Indeed, an FAO consultant to the Irrigation Agency advised that 'Iran must build small dams.'[9] This discussion excavates the

machinery of the decision-making process through which such a large-scale dam project was conceived and built when World Bank and FAO experts alike deemed it a high-risk venture from the start.[10]

The analysis is based on archival research at the World Bank Archives, the US and British national archives, the papers of the Development and Resources Corporation, and Iranian hydraulic engineering journals and periodicals. The paper is divided into the following sections: (1) a brief discussion of scholarship and the use of analytical tools from science studies to investigate this large-scale infrastructural project; (2) a discussion of the origins and points of convergence that helped mobilize cost-benefit analysis through river planning globally; (3) a discussion of local practices of water management in southwest Iran; (4) a discussion of the variables used in calculating the feasibility of the dam project; and, (5) a discussion of the uncertainties attached to the productivity of Khuzestan's soil followed by concluding remarks.

Governing Hydro-Political Futures for a Profit

Political histories of Iran highlight the Dez Dam's construction as the embodiment of broader trends of state planning and centralization that motivated political elites in large-scale modernization and nation-building projects (Bostock and Jones, 1989; Halliday, 1979; Katouzian, 1981; Keddie, 2003; Nasr, 2000). In contrast, scholarship in environmental history (Sneddon, 2015a; Tvedt, 2010; Unger and McNeill, 2010) and science and technology studies (STS) (Alatout, 2009; Barnes, 2014; Bijker, 2007; Carse, 2014; De Laet and Mol, 2000; Pritchard, 2011) has taken seriously the sociotechnical properties of water, its multiple ontological natures, and the consequences for politics (Bakker, 2012). This study builds on such scholarship and the material turn in Middle East Studies (Barnes, 2014; Jones, 2010; Meiton, 2013; Mikhail, 2013; Mitchell, 2011b; Shokr, 2009) by placing the infrastructural work of the

Dez dam project at the center of the analysis to explore its entanglement in new forms of engineering and economic knowledge. Drawing on tools from STS, I investigate the ways in which the calculation of risk generated by the device of cost-benefit analysis of neoclassical economics became the most influential language for explaining and organizing the relationship between humans and nature in Khuzestan.[11] The technological system centered around the dam generated hazards and controversies it was not capable of controlling. In the process of its construction, the materials of the dam were bound up with the production of information not only about water and the dam itself but the project's impacts (Barry, 2013: 19). The convergence of the novel concept of integrated river basin development with economic statistics played a vital role in demarcating a space for intervention that precluded an analysis of land inequality, the hierarchy of sociotechnical relations, and power struggles.

Like the Dez River, the Nile, the Jordan, the Tigris, the Euphrates, and many other rivers of the Middle East were dammed up and diverted in the mid-twentieth century on a scale far larger than the undertakings of the colonial period. As Mitchell (2011c: 267) explains, 'the dams would store up the rivers' waters, eliminate systems of flood-basin irrigation, and replace the river and its carefully managed seasonal abundance with a permanent arrangement of barrages, canals, irrigation channels, and diesel pumps.' Forms of measurement, know-how, and control previously dispersed across millions of hectares of floodplain increasingly concentrated at a single site. This concentration of management and information contributed to ways of governing that 'took the management of nature as their object, and the representation of nature as their project' (Mitchell, 2011c: 270). Decisions, reports, reconnaissance flights, river basin surveys, and engineering schemes helped manufacture new ways of seeing the natural world in terms of techno-economic calculation and description, demarcating a space for expert intervention

(Porter, 1996). The novel tools of economic statistics and national accounting mobilized development concepts formalized by the articles of agreement of the new Bretton Woods Institutions established in 1944 – the World Bank and the International Monetary Fund (IMF) -- to manage post-war development in the so-called third world states (Cooper and Packard, 1997: 7; Finnemore, 1997: 206). Transnational economic expertise such as statistical tools for calculating poverty levels, per capita income, balance of payments, standards of living, and employment converged with national infrastructural projects of damming the rivers of the Middle East.

As a centrepiece of post-war nation-making in the Middle East, US-based government aid agencies, institutions of global economic governance, private American investors, engineers, and agricultural scientists converged in Khuzestan to transform the region, its water, and its farmers into a laboratory -- ideal-type models of 'grass-roots democracy' and economic and social development on a grand scale (Ekbladh, 2002b; Embry, 2003). Organized around the technicized space of the damming of a river system and transforming its energy into unlimited hydropower, the constant failures confronted by the project led to the proliferation of economic, scientific, and technical reports that constituted what Callon et al. (2011: 233) has called an 'enterprise of concealment' to eliminate controversy. This enterprise was evidenced in economic feasibility reports for the calculation of the risks attached to the project. Scholarship and feasibility reports alike explain away the failures of the dam project as the product of patrimonial politics, bureaucratic mismanagement, inefficiency, corruption, and the persistence of traditional agriculture and water management methods.[12] The notion of risks and hazards in scientific and industrial development is associated with that of rational decision-making but does not permit one to describe situations of 'uncertainty' or other interests that are said to lie outside the frame

of the rational (Beck, 1992; Callon et al., 2011: 19-20).[13] By taking seriously the technicality of the battle within the decision-making process of building the dam, I open a wider frame of political dynamics, technical interventions, and social relations involved in governing democratic futures by assembling Iran's waterways in the infrastructure of international development.[14] The downward flux of water through the soil and the upward passage of salts was as important to agricultural productivity as the flow of water access at the surface but could not be factored in calculations of the costs (Barnes, 2014: 167-168). In practice, cost recovery and integrated water resources management failed to account for local practices of water production, distribution, and use, or the ways in which the materiality of flows and technologies shaped how different forms of dispossession occurred (Barnes, 2014: 113).

Building the dam required putting in place a future, an economy, through which Iran would now be governed. Mitchell (2014a: 506-507) has explained this peculiar relationship to the future with regard to another World Bank-funded dam project at Aswan in Egypt. Large infrastructure projects such as dams produced future returns that could be calculated at the level of the economy, making the sovereign state liable for the loans rather than the private enterprise. In southwest Iran, feasibility reports indicated that risky measures of damming and diverting water flow and overcoming obstacles posed by the region's saline soil could be managed by leaving them to the care of economic mechanisms to resolve emergent political and social issues of land reform and water rights (Callon et al., 2011: 227). The decision-making process involved in policy planning and calculating costs and benefits did not factor the organizational work of statistics peculiar to a specific configuration of 'state and market' in the mid-twentieth century (Desrosières, 2003: 553). The period was marked by a shift in global economic knowledge that involved new methods of counting and comparing income in relation to the unit of the nation-

state (Speich, 2011: 10-11; Macekura, 2015: 30). Novel techniques of governance were co-constructed with new modes of data accumulation and logics of abstraction (Speich, 2011: 20). Over the course of three decades, proposed solutions were aimed less at rectifying water, land, and farmer disputes, than at providing a way for devising novel technologies of governance over the countryside.

Globalizing River Planning through Cost-Benefit Analysis

Iran's economic development law of September 1948 marked the birth of the Plan Organization (PO) as an autonomous governmental agency established in 1949.[15] Led by Abol-Hassan Ebtehaj (1954 to 1959), former head of Iran's National Bank (*Bank Melli*), its goal was to fund economic development projects across the country. The Ford Foundation and the World Bank supplied Ebtehaj with financial and technical assistance in this institution building. The Foundation enabled Ebtehaj to hire a team of advisors from the Harvard School of Government to recruit and train a group of Iranian technocrats for the PO (Baldwin, 1967). Both the Harvard advisors and the Iranian recruits were PhDs trained in the Anglo-Saxon school of development economics.[16] Under Ebtehaj's leadership, the PO's powers were transferred abroad through the direct intervention of a private enterprise, the Development and Resources Corporation (DRC). David E. Lilienthal, former chairman of the TVA, founded the American consulting group in 1955, and along with his successor, Gordon Clapp, advised Colombia, Puerto Rico, Iran, and South Vietnam on numerous modernization projects in coordination with US-government technical assistance programs (Ekbladh, 2002b: 351; Clapp, 1957; Lilienthal, 1959b: 132-139).[17]

In the same year, an Iranian hydraulic engineering journal, *Ab* (Water), proposed economic development programs for each of the large rivers in the country.[18] American and Iranian infrastructural development experts alike depicted the Khuzestan region in contrast to a

more verdant and fertile past, or a more prosperous and well-irrigated future which Western technical and economic assistance would help bring about (Figure 2).[19] They relied on geographer accounts of thriving agriculture in the 10th century, particularly sugar cultivation of the province, which acquired the name 'Khuzistan,' referring to the land of the *Khuzi* people (or *Huzi*), said to have originally meant 'sugar cane' (Bagley, 1976: 26).[20] The failure of local populations to achieve natural resource abundance became one of the key justifications for regimes of international economic governance and finance to intervene with loans and technical know-how.

American public and private enterprise converged in the political project to build the Dez Dam. German engineering surveyors first studied the feasibility of building a dam in the gorges of the Dez River in the 1930s (Tucker, 2010: 149-150). After the war, they were in no position to compete with the Americans who in 1956, conducted an aerial reconnaissance survey discovering 'an ideal but challenging site' for a high dam in a 1,200-foot-deep canyon.[21] An American civil engineering firm, Morrison-Knudsen, won the contract to build the access roads, diversion tunnel, and construction camp in 1958-59 but lost the main contract to construct the dam and spillways to an international consortium led by Impresit, an Italian civil engineering firm, with the US and the UN providing technical oversight. Morrison-Knudsen's connection to the project stemmed from having previously helped achieve the breakthrough in the design of dams in the US through its participation in a consortium of the 'Six Companies,' which included Bechtel. In coordination with federal agencies, the six firms built the famed Hoover Dam, an arched dam made of concrete. Morrison-Knudsen and Bechtel used their experience and profits from the project to become the most powerful international construction firms after 1945 (Tucker, 2010: 140). More innovative than the dam's design was the coordination of economic

and social development throughout a river basin around key points of major dams. This was achieved in the form of the New Deal's showpiece, the TVA. Thus, the US played a dominant role in the 'domestication' of major river systems globally and the Dez Dam in Khuzestan was the designated showpiece for demonstrating the success of the transplantation of the TVA model to the developing world.

US-led globalizing river planning -- the design of large dams and the implementation of the integrated river basin concept – could not simply be imposed. A less visible actor emerged in the format of cost-benefit analysis to help appraise the risks or the economic costs and social benefits of river basin development concentrated at the site of a dam. Multipurpose river development and accounting shaped the ways that experts at the DRC and the PO rationalized river planning. The goal was to develop not just physical resources (land, people, water), but the location-less economy in terms of growth (e.g. national income), which was a prevalent method used by governments. Like the Aswan High Dam in Egypt, the reliance on economic models for calculating the desirability of a public works project and the opportunity cost of undertaking the project enabled dam construction to be 'sanctioned by the logic of state investment in economic growth and…justified as economically rational behavior (Shokr, 2009: 25).' The language of multipurpose development and the possibility of achieving it in one massive project was vital to a regime's perception of why dams were so important to economic development.[22]

Cost-benefit analysis traveled the world by flows of water. Its incorporation in public decision-making originated in government planning dating back to attempts by the French Corps of State Civil Engineers to appraise the social benefits of public infrastructure projects in 19th century France (OECD, 2006: 16). Most notable from this group was the Italian-born economist and engineer, Jules Dupuit, who was among the first to analyze the economic problems, or the

'cost-effectiveness,' of public works projects with regard to water flow and charging French consumers for its use.[23] By the 1920s-30s, the concept of 'externality,' the cost or benefit that affects a party who did not choose to incur it, was formalized within the theory of welfare economics.[24] In a parallel development, the US Rivers and Harbors Act of 1927 helped formalize flood control, navigation, power policy, and irrigation as one unit of development. It authorized the US Army Corps of Engineers to apply cost-benefit analysis to determine the feasibility of waterway projects (Porter, 1996: 148; White, 1957: 170). The subsequent TVA Act of 1933 consolidated the river as a unit in legislation (Wengert, 1952). It transformed the Tennessee Valley into a pilot project targeted by the Army Corps of Engineers to test integrated river basin development and demonstrate the program's feasibility (White, 1957: 171). Along with the US Bureau of Reclamation, established in 1902 in response to the need for massive irrigation systems to water the arid states of the American West, the Army Corps of Engineers provided 'the world's largest cadre of experienced river basin managers by the 1930s' (Tucker, 2010: 140).[25] After World War Two, these two agencies were well positioned to become development advisers to governments around the world and were available to lead feasibility and pre-investment surveys. By the 1950s, the complex forms of calculation required by dam construction gave rise to the formal economic field of cost-benefit analysis which development experts and national planners used to appraise the Aswan High Dam in Egypt, the Pa Mong Dam in Southeast Asia, and the Dez Dam in Iran (Tucker, 2010: 140).[26] The waters of the Dez River and other major rivers of the world shaped the building of large-scale infrastructural projects around dams, but they were simultaneously entangled with the production of economic information about the costs and benefits to the local population, making possible the development of new methods of governing democracies in terms of risk.[27]

In order to calculate the costs and benefits of global river planning strategies at the local and national levels, new forms of technical and economic description of Iran's waterways were required that did not previously exist. The American and British governments agreed that the Middle East provided an ideal setting for the absorption of international development 'specialists' such as surveyors, statisticians, meteorologists, soil chemists, industrial chemists, and economic entomologists.[28] The two governments hoped that with financial support from the World Bank, 'the attitude of the Middle East governments towards development might become far more positive….'[29] In 1948, the US Ambassador expressed particular interest in the development of Khuzestan's sugar cane industry and wheat growing.[30] The passage of Iran's economic development law marked the generation of novel forms of national statistics and an official 'Handbook of Agricultural Statistics of Iran' compiled by Gideon Hadary, research attaché at the American Embassy in Tehran.[31] By the 1950s, Clapp and Lilienthal, the former directors of the TVA, were well positioned to advise Ebetehaj and the PO in the economic transformation of the Dez River, understood in terms of agricultural and industrial output.

Technical practices in economics and engineering mixed with ideas of development and progress in *Ab*, the Iranian hydraulic engineering journal.[32] Discussions reveal a concerted effort among engineers and development experts to collect quantitative data on the country's rivers, the risk of flooding, and the costs.[33] The use of demographic statistics correlated with cultivated surface area helped illustrate Iran's unfolding crisis. A growing concern was the problem of 'water scarcity' in connection with the urgency of feeding larger populations, addressing population growth, the rising prices of foodstuffs, and supporting increased agricultural productivity.[34] TV Andersen, from the Agricultural Division of the Department of Technical Operations at the World Bank, echoed these concerns arguing that alongside the problem of

'overpopulation' of agricultural land, the scarcity of water, not land, was the 'general limiting factor' to Iran's increased agricultural productivity.[35] The problem of supporting a larger population (rural population of 16 million) in relation to the cultivated area (5 million hectares) and the income generated from agriculture was now discussed in relation to the much bigger problem of national income. Combined with Iran's complicated land tenure system, this produced a living standard at the subsistence level (10-12,000 *Rials* of net income). There was one family to every 1-2 hectares of cultivated land indicating to experts that productivity per man hour and per area unit was low. Framing rural poverty in terms of natural resource scarcity and over population enabled experts to avoid questions of wealth and land redistribution.[36] Iran had spent the past decade gathering the relevant data but more engineering expertise was required to understand the novel properties of water in cubic meters, the science of water measurement, and climate statistics.[37] New formulas were devised for calculating whether irrigation was necessary in a particular area.[38] Relying on standardized equivalencies for calculating the profitability of water made Iran's water problems visible, leading to the contention among some engineers that there was a need for many small dams to collect spring and winter waters.[39] In the post-World War II order, development practitioners, social scientists, engineers, and national planners coordinated in enrolling the device of cost-benefit analysis to transform Iran's waterways into techno-political matters of local, national, and international concern.

Democratic Voluntary Operation

The goals of globalizing river planning strategies were in stark contrast to older understandings of rivers and local practices of water use which did not refer to water as a simplified 'resource' amenable to manipulation through 'unified river basin' or 'water resource management.' The unified concept was new but not the importance of water for farming, power,

and navigation, which was discussed in prewar-Iranian and western scientific journals. Knowledge about water was dispersed and the flows of a river were not an obstacle to be overcome with technology or a set of resources, restrictions, and risks open to foreign intervention (Mitchell, 2011c: 266). Specialists in the natural and environmental sciences and commercial geography produced the first Western accounts of Iran's waterways in the 19th century (Curzon, 1890; Graadt van Roggen, 1905; Layard, 1846; Rawlinson, 1839; Shelby, 1844). Visions of environmental neglect or possibility framed geographical descriptions of the country's rivers along with maps detailing steam navigation routes to justify the intervention of British colonial enterprise. Farmers in Khuzestan, however, practiced their own forms of water management and land ownership that had nothing to do with 19th century orientalist imaginaries of the environment or 20th century TVA models of multipurpose river development.

The nature of a river's water was integrally related to the nature of the land. The existing land tenure system in Khuzistan was known as *bonku* (Salmanzadeh and Jones, 1981: 207). According to Salmanzadeh and Jones (1981), each year prior to winter and summer cultivation, the farmers would form themselves into a number of *bonku*s of up to five people. Membership in a *bonku* was voluntary and not necessarily permanent, often arising from friendship, trust, and family ties. Members of each *bonku* selected a representative, the *sarbonku*, who would participate in the drawing of lots for seasonal land allotment. He was also in charge of collecting dues from the members for the village functionaries (e.g. the irrigator, the protector of the fields, and so on) and organizing communal work, such as cleaning and repairing the village irrigation ditches. Andersen, the World Bank agricultural expert, viewed this 'democratic voluntary operation' as too complex because it 'considerably impede[d] improvements and changes in

agricultural methods.'[40] But forms of land ownership and water use implemented in the American South could not simply be transported to a small corner of southwest Iran.

Practices of basin and perennial irrigation persisted in Iran prior to the emergence of the modern dam.[41] Due to the absence of surface water in many parts of Iran, Iranians first invented an ancient water system maintained throughout the country known as *qanat* or 'vertical shafts connected by gently sloping tunnels that direct water from higher regions with no need for pumps' (Keddie, 2003: 151; Beaumont, 1974: 421). A 'special aspect of [Iran's] ancient irrigation was [that] water was artificially lifted from canals to the fields…automatically reduc[ing] the danger of over-irrigation and salination.'[42] Accessing and using water from the *qanat* was relatively cheap but could not be considered a reliable source of water supply due to its dependence on ground water levels (Ghazi, 1977: 598). According to the theory of cost-benefit analysis, seasonal variation in the *qanat* discharge translated as 'wasted' supply during winter months when agricultural demand for water was low whereas water was in short supply during summer months when water river discharges were minimal (Ghazi, 1977: 598; Beaumont, 1974: 421). Carefully managed seasonal abundance was not the goal of large-scale irrigation and agriculture. Rather, its goal was the maximization of water use and distribution for year-round economic productivity.

The *mirab* was the water distributor in the village nominated by local landowners but not necessarily living in the village (Ghazi, 1977: 77). The old regime of main canals and their branches was governed by the water level of the rivers (Ghazi, 1977: 176-177). Strict regulations governed ownership of the canals serving the fields, belonging either to one or a group of landowners. Working on behalf of landowners, water distributors were responsible for the de-silting of canals and the construction of temporary diversion works. The construction of

brushwood and stone dams, for example, dated back over a hundred years helping to divert water to the fields through a hand dug irrigation channel network.[43] With a short supply of water for agriculture, irrigated land in Khuzestan was discussed in terms of minutes or hours of water application.[44] Farmers did not pay for water nor was the amount controlled, and the ownership of water was not necessarily in the same hands as the ownership of land (Salmanzadeh and Jones, 1981: 202, 197). These complex collectives of water management, distribution, and ownership emerged within local ecologies of agriculture, settlement, land and water use which were not concentrated at one site or understood in strictly economic terms.

The establishment of the Independent Irrigation Agency in 1943 distributed greater state control over irrigation practices, which also extended to non-state owned *qanats* (Ghazi, 1977: 176). The Agency was authorized to form 'boards' for ensuring the regular division and distribution of water and the maintenance of water works, consisting of a collective of 'landlords and the people receiving water supplies' (Ghazi, 1977: 77-78). The land reforms of the 1960s enabled the Iranian government to exert further control over the countryside by redistributing land from a few powerful landowners (Salmanzadeh and Jones, 1981: 202). The 1968 nationalization of water resources transformed water into the natural wealth of the nation, authorizing the Ministry of Water and Power to issue permits for water use (Beaumont, 1974: 418-419). In practice, however, the *mirab* still oversaw the division of water but was empowered by the 'Regional Power Authorities' such as the Khuzestan Water and Power Authority (KWPA). Thus, the powers of the local water distributor in rural areas remained significant given his close ties to absentee landowners and later, with water authorities.

The PO-initiated multipurpose water projects in Iran, including a number of large reservoir dams (Beaumont, 1974: 418-419), coincided with state-led reforms to redistribute land

and compel farmers to cover the costs of a dam by paying for the use of irrigated water. In coordination with the DRC, World Bank, and US government agencies, these actors laid the groundwork for generating novel perceptions of the basin in a concentrated space. Isolating the forces of nature at the gorge of the Dez River made them more easily observable, manipulated, harnessed, described, and represented (Mitchell, 2011c: 271). But as Latour (2004) observes, the possibility for 'recalcitrance' of natural forces such as the soil meant that their representation was not merely a cultural construction, for the same forces retained their enormous power to refute what was said about them, escaping mechanisms of control, or producing unexpected actions. Flows of river water and local practices of water use were entangled in the infrastructural work of appraising the dam's impacts giving birth to the globalizing river planning of international development, that is, the corporate power of DRC and economic governance of the World Bank. Their planning and provision involved negotiating new questions of scarcity, fair distribution and calculating the costs and the benefits to the local population. But Khuzestan's recalcitrant soil proved less governable than FAO soil scientists, World Bank appraisers, river basin surveyors, and aerial reconnaissance missions had assumed.

Calculating Economic Feasibility

By commencing its first "Seven Year Plan" in 1949, Iran joined the initial wave of non-western governments to adopt economic planning programs in India, China, Egypt, and Turkey.[45] Drafted by Ebetehaj, the plan was very similar to the ethos and goals of the Bretton Woods Institutions with a proportion of the funds targeted at agricultural and infrastructural projects (Bostock and Jones, 1989: 95). Iranian technocrats proposed that one-third of the funds, or approximately $200 million dollars come from the World Bank and two-thirds come directly

from the PO, which would be granted complete autonomy by relying on Iran's oil revenues, flowing from the oilfields of Khuzestan province.

By 1958, thirty European and American consulting engineering firms operated in Iran with one exception, the DRC, which retained executive authority to lead the regional development program in Khuzestan (Bostock and Jones, 1989: 123). Ebethaj first met with Clapp and Lilienthal at a joint IMF-World Bank meeting in Istanbul. With pre-approval from Eugene Black, head of the World Bank, Ebtehaj invited Lilienthal to Iran to 'investigate development possibilities' (Ekbladh, 2010a: 135). Ebtehaj believed that large-scale dams and irrigation projects were a necessary foundation for economic growth (Ekbladh, 2010a: 131). Since the 1930s, he campaigned for the formation of an economic bureaucracy to lead Iran's rapid development plans, culminating in the creation of the PO (Nasr, 2000: 100). Ebtehaj was a 'growth man' who measured success by high growth rates and 'rational behaviour and decision-making' (Bostock and Jones, 1989: 89, 128). Surprisingly, Lilienthal was 'unfazed' by the FAO's warning about Khuzestan's soil salinity problems and poor climate.[46] As a new kind of political actor in the twentieth century, the DRC aimed to sell 'self-help--at a profit' (Lilienthal, 1967).

DRC reports conflicted with the vulnerabilities of the dam project identified in the World Bank's feasibility studies first drafted in 1959. The DRC argued that integrated river basin development on the Dez River would bring agricultural productivity, power generation and flood control, a sugar industry, ammonia plant, fertilizer production, petrochemicals, plastics, and electricity.[47] Iranian hydraulic engineers agreed with their foreign counterparts, claiming a six-fold increase in productivity.[48] To facilitate early loan discussions in 1957, the PO requested that the Public Domain Office of Khuzestan confirm that the lands targeted for dam development

were ‘unoccupied’ and not claimed by title.[49] Overlooking the foreseeable controversy in confronting local claimants to the lands, the PO expressed a willingness to take the ‘necessary measures’ to convert property ownership from local title holders to the DRC.[50] But the submission of feasibility reports was an unavoidable condition for receiving a World Bank loan. Thus, formulating the probable risks attached, the calculation of land and resettlement costs, including the properties that would be submerged under water, needed to be factored in any economic justification put forward by the PO.[51]

The Department of Technical Operations’ draft report concluded that the Bank would ‘not be well advised to lend money’ for the Dez project.[52] Loan discussions between Lilienthal, Clapp and the Bank concerned the 1959 report which proposed two cheaper alternatives for irrigation and power based on thermal power. A Bank representative argued that ‘Iran should learn how to crawl before it tries to walk’ because the ‘return on investment shown for the project is not too favorable and the risks are great.’ Problems of organization, policy, and the uncertainties attached to the irrigation program rendered the Dez project ‘so risky’ that other regions of Khuzestan were deemed more favorable. DRC representatives countered that the economic feasibility of the Dez dam was ‘guaranteed by its power and flood control benefits.’ This would ‘offset’ some of the risks of the irrigation program. The ‘greatest advantage’ of the multipurpose water control program was that power potential could be considered as a ‘paying partner…yield[ing] quite a substantial margin’ to support other aims.[53] Discrepancies persisted in the analysis of the benefits of flood control generating a World Bank estimate of $40 million versus a DRC estimate of $75 million. The DRC argued that its estimation was based on a ‘careful study of the facts’ leaving no justification for reducing their figure. The language of cost-benefit analysis enabled the DRC to maintain its negotiating position, arguing that

discrepancies in calculated figures of the benefits appeared to pivot on the Bank's 'present value method of computation' which favored thermal-based power generation. Both sides agreed, however, that there was 'more than one agreeable basis for cost analysis.' Depending on the terms of computation and the stakes, the hydro-power project was both feasible and infeasible.

There was an ambiguity internal to the decision-making process not only about the calculation of flood control costs, irrigation, and power, but the benefits to the local population. Unable to receive a clear response from the PO and its American partner regarding the nature of property relations and water rights in the region, Bank officials proposed that Iran undertake a three-year test case as an economic justification for the extension of the greater Dez project (Figure 3).[54] Commenced in 1959, the "Dez Pilot Irrigation Project" (DPIP) encompassed 22,000 hectares and a population of 13,800 people living in 57 villages of an average size of 45 families (Ghazi, 1977: 215). Eighty percent of the pilot area was inhabited by locals from the main city of Dezful, five percent by Arab nomadic groups, and 5.6 percent by the Bakhtiyari nomadic group. The goal of the pilot area was to assess the ability and willingness of the population to adjust to new technologies of water control and management under the KWPA, the new government agency which had taken over from the Khuzestan Development Services first set up to operate on behalf of DRC in Iran. A period of ten years was granted for the 'full transition to modern farming methods in the area' (Ghazi, 1977: 212-213). The KWPA initiated fertilizer trials with FAO help. Satisfied with the control mechanisms in place for monitoring the socio-economic impact of the dam project, the Bank granted its first loan of $42 million dollars to the Iranian government in February 1960.

The pilot area was being transformed in order to make of the outside world, Khuzestan province, a place in which high value crops would thrive on the hydro-power of the Dez Dam.

Khuzestan served as a site for transformations of the material and political world densely imbued with expertise (Mitchell, 2011b: 139). The readiness with which it seemed this world could be manipulated and modelled by cost-benefit analysis reflected not simply a naturally quantitative world but the imbrication of conceptual machineries and calculations of economic science in the world it was studying.

The loan coincided with the involvement of the Bank's sister organization, the IMF, which prescribed an austerity package to the Iranian government triggering a severe recession and balance of payments crisis (Nasr, 2000: 99). The 1960-62 economic crisis was connected to the monarch's decision in 1959 to remove Ebtehaj from power due to allegations of corruption and place the PO under his cabinet's supervision. Political challenges including high unemployment and the regime's decision to break its alliance with landowning classes through land reform informed the Shah's decision to give economic initiatives an 'air of nationalism' (Nasr, 2000: 100-101). Iranian economists concurred that economic growth necessitated the establishment of an autonomous national economic bureaucracy. The Ministry of Economy was formed one month prior to the inauguration of the Dez Dam in 1963.

In the following years, tests proliferated to assess the impact of 'high-value crops' such as cotton, sugar beet, and alfalfa within designated trial farms. The 'Safiabad Agricultural Research Center,' and a soil and water laboratory were established in 1962, and the first two phases of the Shah's controversial land reform program, known as the 'White Revolution,' were executed in the pilot area (Ghazi, 1977: 220, 222).[55] Over 54,000 plots and trials were established for 'testing purposes' throughout Khuzestan, but concentrated mainly within the DPIP area.

Like the Dez irrigation program, the project to build the Haft Tapeh sugar plantation and refinery at the southern end of the project area was both feasible and infeasible depending on the interests at stake and the costs to the local. The FAO report on sugar cane culture, submitted to the Iranian government in August 1953, highlighted the potential risks and the lack of scientific data for assessing its economic feasibility.[56] A DRC report revealed that the warnings had not deterred the government's agenda in Khuzistan: 'A major step toward self-sufficiency in sugar supply and restoration of cane culture in Iran were the transcending policy objectives advanced for this project.'[57] By the 1960s, the project was deemed economically feasible in relation to the future. It would 'pay for all of its running costs….and yield a margin of income when it reache[d] the planned harvest of 4,000 hectares.' Most crucial, '[a]s the interest of private landowners in cane culture grows, the wisdom of the concept of the demonstration will be proven. This is the acid test of economic feasibility.' The interests of the local farmer were calculable as long as he remained interested in the project to build a sugar cane industry.

Economic feasibility reports informed the decision-making process throughout loan discussions. The reports relied on a set of calculations about the 'economic return' from the development of high value crops such as sugar cane, the net value of production correlated with the percentage of land irrigated, the amount of hydro-electric power generated, farmer income levels, and the 'quantification of farmer satisfaction.'[58] Access to these calculations were the condition on which Bank officials claimed they would grant future loans to extend the project from the pilot area. Loan officials lamented the lack of maps and data, demanding greater transparency from the DRC regarding power generation, fiscal information, and water charges.[59] DRC's reports lacked information concerning the nature of land ownership among farmers, productivity levels, and problems with the KWPA 'overdesigning' the pilot area and the

proposed extension.[60] It was 'hard to believe,' the Bank admitted almost a decade later, that soil scientists 'missed' Khuzestan's soil permeability problem.[61] On the other hand, the Bank wanted the dam project to succeed in order to 'absorb substantial amounts of bank finance.'[62]

The proliferation of costs and inadequacies of the feasibility reports did not deter the World Bank from supporting the second phase loans to the PO for the greater extension on the remaining 75,000 hectares. The Bank accepted DRC's 1966 feasibility report and agreed to waive the 3-year test period.[63] In reality, the DRC had provided so much technical and economic data that Bank experts could not assess the material in the time allotted. They could not assess what 'happened to the position of the average cultivator nor whether the benefits of the project are distributed fairly evenly or concentrated among a few.'[64] On the Iranian side, the KWPA deemed the pilot project a success and that it would proceed with or without the Bank's support.[65] As proof, Safi Asfia, Ebtehaj's replacement at the PO, confirmed the 'satisfactory' accomplishment of the work funded by the first Bank loan with a glowing review.[66]

With his grand plans to industrialize and modernize Iran, the Shah was in a rush to win over public opinion, but the feasibility studies were incomplete.[67] A Bank mission to Tehran in 1967 emphasized the persisting problems in marketing, resettlement of farmers, and the layer of impermeable soil.[68] Yet John Knapp, vice president of the Bank, saw no reason to delay the extension of the Dez project into its second phase. Writing to Knapp, a Bank official surmised that 'we would help the Greater Dez project most by staying in the picture….'[69] The Iranian government pursued the project extension by inviting agribusinesses based in California (Figure 4).[70] A 1968 law for 'The Establishment of Companies Downstream of the Dam' granted long-term leases to US-based agribusinesses to level the land for capital-intensive, mechanized farming.[71] A DRC official assured Asfia of the benefits: 'Using what we think are conservative

figures for both costs and benefits, we have made economic analyses according to formulas prescribed by IBRD [World Bank], and arrive at an attractive internal rate of return.'[72] The only concern, he confessed, was certain 'assumptions' about lot sizes that would be made available to agribusiness enterprises calculated in terms of the 'optimum benefits' produced. These assumptions, the official warned, 'run through the report. Should they prove invalid, we are in trouble.' A 1967 USDA report revealed that the lowest average cost in a mechanized, capital intensive process of production was estimated to occur on 640 acres or less, but Dez agribusinesses aimed to cultivate crops on lot sizes amounting to thousands of acres (Richards, 1975:18). To secure World Bank finance, the Iranian government ignored the costs to the local and pursued a line of economic analysis insisting that the pursuit of commercial agriculture in the greater Dez area was necessary to achieve a 'reasonable level of production without substantial delays and a satisfactory return on investment.'[73] There was no better place than Khuzestan for demonstrating to the world that agribusiness was 'serious about demonstrating what can be done through modern methods and management' to 'contribute more effectively in the crisis the world faces because population is growing faster than world food supplies.' Prioritizing foreign investment would provide Iranian technocrats with the necessary evidence for growth. On its end, the Bank did not want to lose its client.

The Bank's working party concluded that the project was 'technically sound and economically justified.'[74] They reasoned that Iran's second phase of land reform, working through credits to farmers, would help eliminate future obstacles. In 1968, as the Iranian delegation pushed for a significant expansion of land area available to agribusiness and commercial agriculture from 3,000 to 58,000 hectares, the Bank insisted on a smaller figure of 20,000 hectares provided that those areas would 'revert to improved traditional farming' by

certain cut off dates.[75] In negotiations with the KWPA and the Iranian government, the Bank admitted that its knowledge of what was really going on in the DPIP 'is practically nil.'[76] The KWPA's accounting methods were inconsistent and omitted information on whether registered ownership was based on the cadastral survey.[77] The KWPA feared that a reliance on villagers to increase productivity would not provide the desired results in economic terms.[78] Farmers were restricting cultivation rather than increasing productivity to avoid paying the costs of access to irrigated water (Salmanzadeh and Jones, 1981: 202). In justifying the reversion to abandoned agricultural practices that development practitioners first touted as backwards, the Bank admitted that there was 'no proof' that modern agricultural farming techniques were better than their traditional counterparts.[79] The change in attitude marked the demise of the TVA model in the late 1960s and a broader shift in the international community's perception of development as technologically driven modernization.[80] The first goal of any project should now be poverty elimination and 'meet[ing] the basic needs of the people they were aiming to help rather than imposing large projects that were often focused on raising economic indicators.'[81] Until the 'superiority of agribusiness is proven,' a Bank official warned, 'nothing will be done to jeopardize the development of the traditional farming.'[82] The second Bank loan was finally granted in April 1969 for $30 million, justified by meeting Iran's increased food requirements and reducing its dependence on imports of wheat, sugar, and vegetable oils.

As with other dam projects in the Middle East, cost-benefit estimates ignored 'knottier issues such as disrupting the cycle of siltation, disease vectors in the future reservoir, and other environmental risks' (Tucker 2010: 146). The cost-benefit estimate for the Aswan High Dam in Egypt stood unchanged for over a decade, 'politically insulated by Nasser's circle from scientists' questions about evaporation and seepage of water in the system.' As in Iran, World

Bank experts 'conformed to the Egyptian government's determination to move ahead' and 'failed to raise questions about sedimentation….' Though characterized as a technical problem of oversight or miscalculation within a closed circle of political elites and technocrats (Rycroft and Szyliowicz, 1980: 61), cost-benefit analysis played a central role in the decision-making process of infrastructural development because it enabled the management of favorable outcomes and unruly actors such as the soil (Li, 2007: 123). The computation did not permit factoring the costs to farmers, issues of land inequality, and political struggles. The effect was to weaken the possibility for building durable and productive structures for future collective life. Relying on the tools of cost-benefit analysis to determine the economic feasibility of a dam enabled, transformed, and inhibited ways of thinking and living collectively. Nature or the water was produced in the spaces, flows, measures, and calculations of building the dam.[83] Both human and the natural took shape in sociotechnical struggles over calculating the future and building access to supplies of water, land, and power.

Recalcitrant Nature

For over a decade, the impermeability of Khuzestan's soil created an inherent uncertainty in the calculation of the risks attached to the Dez dam, power and irrigation, and sugar cane projects. On the other hand, the soil's biophysical characteristics played a pivotal role in the maintenance of techno-political relations organized around the water-based energy system (Sneddon, 2012b: 580; Mitchell, 2002d: 49-51). By the terms of cost-benefit analysis, the insubordination of Khuzestan's soil was a negative externality that could not be factored into calculations of the project's feasibility or justifications for a loan. The severity of the problem was addressed during the 1967 Bank mission to examine both the DPIP and the DIP. An official reported that the problem of 'impermeable strata within the normal rooting zone of crops' was

consistently 'omitted.'[84] Neither the FAO nor the Dutch sub-consultants to the DPIP had 'properly identified' the issue in any of the soil and drainage surveys conducted between 1952 and 1962. The report concluded that there was 'inadequate evidence to support many of the crop production assumptions and market projects….' Neither KWPA nor the DRC could explain why the problem was overlooked in feasibility reports submitted to the Bank by the terms of the loan.

The soil controversy persisted during a subsequent Bank mission to the DIP in 1968. Identified as a 'pan condition,' the feature characterized 'layers or horizons in a soil profile that impede water movement,' potentially due to a high clay content.[85] The condition could be 'induced relatively quickly by environmental changes at the soil surface, such as intensification of irrigation' particularly in semiarid soils. A pan condition within the normal rooting zone of soils was a major factor determining whether such soils could be used for agricultural purposes. Under irrigation, 'serious soil moisture management problems' rendered irrigation projects 'uneconomic.' Poor drainage along with salinity problems plagued the Haft Tapeh Sugar Estate within the DIP area. Soil chemical changes were not monitored properly. For the irrigation project to succeed, the pan horizon needed to be 'transported downward into the soil profile' opening up at least two meters of root zone.

The proliferation of techno-scientific descriptions of the soil and economic calculations of feasibility made problems attached to the dam project less salient and its success more likely by eliminating any controversy (Li, 2007). Several soil surveys were conducted in the Dez project area over the years.[86] The FAO Technical Assistance Program conducted the first survey in 1956. The report contained technical descriptions based on a general reconnaissance survey covering 30,000 square kilometers of the Khuzistan plains. The soil was classified based on the 'concept of the great soil groups' describing topography, drainage, parent material, climate,

natural vegetation, apparent productivity and liability to erosion.[87] The Bank mission's report faulted the FAO for 'very weak' classificatory descriptions and mapping of the soil which did not corroborate 'crop production data' and excluded the costs. The survey's land classification was 'weak in chemical data and contained no information on soil impermeability, alkali test, or boron content.' Classification relied mainly on 'visual examination of inherent physical characteristics of soil profiles as exposed by freshly dug pits.' Thus, the 'limiting chemical features of these soils escaped detection' leading to the report's erroneous conclusion that 'salinity was not much of a problem and alkali was not present.' The pilot area was 'undergoing a "freeze up,"' or a 'rapid deterioration of soil structure due to increased activity of exchangeable sodium on the clay, plus increasing amounts of sodium.' Probing the soil and examining the roots of crops including cotton, sugar beets, and alfalfa, revealed that the soils over much of the project area were less than 60 cm in depth at which point an impermeable layer was detected. A much deeper rooting zone was necessary for the crops to thrive. The question of whether the soil problem was a 'deliberate effort' or due to 'oversight' was crossed out in the report and reduced to a technical problem of excessive 'mechanical compaction by heavy cane harvesting equipment.' The proliferation of surveys and reports made the soil problem simultaneously visible and invisible depending on the nature of calculations about feasibility. Though entangled in this enterprise of concealment, natural (and social) forces retained their power to refute what was said about them, escaping mechanisms of control, or producing unanticipated actions with political consequences for assembling Iran's waterways within transnational infrastructures of governance, finance, and expertise.

Conclusion

In 1970, two decades after the initial proposal to build the Dez Dam, a Bank official characterized the execution of the project as a 'comedy of errors,' pointing to the Iranian government's failure to account for older farming methods and local practices of land ownership and water rights.[88] Bank missions were not permitted to visit areas with traditional farming but managed to observe one farm corporation. As the events of the Iranian Revolution riveted the world, the Bank submitted its Performance Completion Report in June 1979. An audit of this report was drafted the following year. The performance report identified problematic outcomes where the local was consistently excluded and suffered the costs of the dam project.[89] The audit confirmed that economic feasibility studies overlooked the interests of local farmers making it possible for US agribusiness to enter Iran, although many of them went bankrupt and left. Bank-funded projects were causing 'the destruction of traditional villages, removal of population,' and 'involuntary' resettlement in 'unfamiliar surroundings….This seems a common characteristic in several Bank projects,' the audit concluded. It also argued that Lilienthal's influence on the Shah's attitude played a significant role in triggering the 'diametric opposition of views' by favouring the introduction of agribusiness and farm corporations against the Bank's advice.[90]

To a development practitioner, factoring local points of view meant gaining an extensive inventory of the ethnic and nomadic composition of the population, the nature of property relations, and the participation of 'qualified' locals.[91] On a visit to Khuzestan in 1965, a British official observed the striking disparities in housing and work between Iranian technocrats and farmers within the project area noting little evidence of 'social mixing' between Iranians and foreign advisers. Despite historical practices of water use and cultivation in the region, technocratic visions of Khuzestan rendered the agricultural population static and in need of western education and training.[92] The Dez Dam project was not simply a comedy of errors, it

produced disastrous results because the TVA model of integrated river basin development did not fit local conditions nor had it worked in South Vietnam or even the US (Mitchell, 2002d: 44-45).

The building of the Dez Dam played a central role in the formation of Iran's national economy and state planning. Novel technologies of aid, debt, and refinancing, introduced after World War II, generated controversies that connected development economics, hydroelectric power, soil improvement, industry, and scientific agriculture. The excesses of violence and the costs spilled into national politics encouraging the pursuit of more plans, loans, reforms, techno-scientific and economic ways of knowing. The outcome was to transform the waterways and agricultural world of Khuzestan province specifically through the management of risk attached to the dam project from the start.

Rather than seeing the risks involved as the product of rational choices, the passive absorption of American development doctrines, or a superficial engagement with development ideas, the decision-making process of assembling the Dez Dam was entangled in the procedural work of feasibility reports, engineering experts, irrigation technologies, and mechanisms of dispossession. I argue that new forms of authority and governance, namely the multinational corporation and regimes of global economic governance, emerged out of the infrastructural work of building the dam through the calculation of risk. In a small corner of southwest Iran, these power relations shaped the expanding technopolitical framework of river basin development globally in the twentieth century. The sociotechnical vulnerabilities that they generated triggered calls for a return to abandoned forms of water management because they allowed for a 'more democratic division of water…[that] does no ecological harm (Keddie, 2003: 151).' Modified *qanat* construction might be a better way to address Iran's current water crisis now that a number

of its lakes and rivers have run dry. Tracing the genealogy of river basin development in Khuzestan helps clarify the complex ways in which the region has transformed from 'wetland to wasteland' (Bozorgmehr, 2014; Javedanfar, 2013; *The* Guardian, 2015).

Economic feasibility reports worked as techniques of intervention and control, but they did not bring greater certainty. In practice, the risks expanded and multiplied, such as risks of riots (from uncontrollable locals suffering the costs in income, health, and property) and the risks of environmental and agricultural disaster. Constraining procedures included the introduction of trial farms, training programs, and research centers for the management of local points of view and the 'general interest' who remained outside the sphere of economic relations (Callon et al., 2011: 16, 235). What we see is that decision-making was not based on indisputable scientific facts and economic theories but a gradual approach that transferred the costs to the locals who, although penalized, were not factored into the decision-making process. Many of the procedures of techno-economic development that were deployed over the course of three decades in Iran involved controlling 'overflows' but without seeking to prevent or eliminate them (Callon et al., 2011: 10, 235).

Following the imbrication of conceptual machineries and calculations of economic science in the world it was studying has exposed that the waters of the Dez River were multiple in nature – political, technical, social, and financial. Iranian government and engineering experts took on the environmental imaginary of development practitioners, but there was no clean break with earlier forms of regulation, knowledge, and resource practices. The nature of water was integrally related to the nature of the land and the political project of remaking the nation. The Dez waterway was not just seen as helping overcome Iran's Malthusian dilemma of

overpopulation and underdevelopment but was a way of developing multiple sectors of the economy within a single unified plan and raising economic growth levels and prosperity.

Whereas studies argue that 'technical concerns lay on the surface of deeper failings with the developmental approach (Ekbladh, 2010a: 231; Scott, 1998),' this discussion centered on the novel political appeal of cost-benefit analysis, which was a useful tool because it allowed actors with different interests to negotiate outcomes and increase their bargaining power. The proliferation of feasibility reports also played a legitimizing function to eliminate controversy, protect future loans, and attract foreign investment. Remarkably, the calculative terms involved in infrastructural appraisal are often taken for granted as something inevitable. Reopening the black box of econo-technical solutions put forward opens the possibility for mobilizing solutions that have greater credibility, techno-politically.

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Notes

[1] *Etela'at*, Dar Khuzestan Barnameh-ye Vasee-i baray-e Eshteghal-e Bikaran, 13 September 1953, 1, 4.
[2] USOM/Tehran to ICA/Washington, 29 June, 1961, National Archives and Records Center (NARA), College Park, MD, RG 286, Box 3; Bostock and Jones (1989): 135.
[3] *Etela'at*, Yek Naghshe-ye Dah Saleh Baray-e Omran-e Khuzestan, (February/March 1954); Beaumont (1974): 424.
[4] Bostock and Jones (1989): 136; Voorduin to Clapp, 28 October 1957, Development and Resources Corporation Papers (DRCP), Seeley Mudd Library Princeton University (SMLPU), Box 691, Folder 5.
[5] Cardon (FAO) to Stassen (State Department), 18 June 1954. NARA, RG 469, Box 2.
[6] TV Andersen (IBRD), 24 April 1958, World Bank Group Archives (WBGA), Washington DC, 1806229; AJ Bakker, FAO Report 533 'Development of Land and Water Resources in Khuzestan, 1956,' in Hanson (KDS) to Folk (PO), 9 January 1960, WBGA, 1806229.
[7] TV Andersen, 24 April 1958, WBGA, 1806229; USOM/Tehran to ICA/Washington, 29 June 1961, NARA, RG 286, Box 3.

[8] Bostock and Jones (1989): 131; O'Brien to Shahmirzadi, 5 November 1965, WBGA, 1854064. See discussion of the two systems in Voorduin to Clapp, 30 October 1957, DRCP, SMLPU, Box 691, Folder 5.
[9] Mosahebeh ba yek Karshenas-e Kharejee, *Ab* 2(10) (February/March 1959).
[10] Nonetheless, World Bank experts advertised TVA-inspired projects in the region. See Bochenski and Diamond (1950)
[11] I draw on a broader argument in Mitchell (2011c): 267.
[12] On the nature of decision-making in the building of a dam, see Rycroft and Szyliowicz (1980).
[13] On risk in the non-west, see Amir (2014).
[14] On dam building projects as the embodiment of a range of politics, see Bijker (2007).
[15] Draft of Economic Development Program Law as Submitted to Majlis, September 1948. British National Archives (BNA), UK, FO 371/68714A.
[16] Bostock and Jones (1989): 122. On the Ford Foundation and economic development in Iran, see Nemchenok (2009): 264. Also, see Cooper and Packard (1997): 2.
[17] The corporation was formed with the international banking house of Lazard Frères. Clapp was head of the UN Economic Survey Mission to the Middle East in 1949.
[18] Hokoomat bar Roodkhaneha-yi Keshvar, *Ab* (December, 1955): 35-37.
[19] For example, Tarikhchehyi Abyari dar Iran, *Ab* (December, 1956): 37-39.
[20] Other accounts date sugar cane cultivation to 500 B.C. See Tarikhchehyi Abyari dar Iran, *Ab* (December, 1956): 37-39.
[21] W Bowman, Iran's Two Big Dams Promise a Better Life, *Engineering News-Record*, 16 March 1961.
[22] This does not detract from the equally significant symbolic value of dams to regimes in power, which the Dez Dam, as the world's largest concrete dam of the period, embodied.
[23] *Britannica*, www.britannica.com/biography/Arsene-Jules-Etienne-Juvenal-Dupuit; Ekelund and Herbert (1999) argue that Dupuit initiated the study of microeconomics which has been attributed to Alfred Marshall and his colleagues in England; Ekelund (1968). The genealogy of the river-basin concept is also discussed in Molle (2009).
[24] OECD (2006): 16.
[25] The former head of the Bureau, William Warne, was a water resources specialist who directed the Point IV program in Iran and the DRC in the 1950s-1960s.
[26] See Mitchell, 2002d: 37.
[27] Mitchell (2011b: 143) identifies two methods: the construction of the Cold War order to police the postwar Middle East and the manufacture of 'the economy,' in the non-west, which occurs as the concept of development without political upheaval.
[28] Enclosure, Charlton to Cabinet (BMEO), 'Annex B,' 11 November 1947. BNA, FO 371/75085.
[29] ?, 25 April 1949, BNA, FO 371/75085.
[30] Le Rougetel to Wright, 18 February 1948. BNA, FO 371/68711.
[31] Report, Stewart to BMEO, 17 December 1948. BNA, FO 371/68714A.
[32] The topic of water resource development was also addressed in an Iranian development economics journal, *Taqlid-e Eghtesad*.
[33] Motal'at-i Sadsazy, *Ab* (1951-52): 11.
[34] Kambud-i Ab ra Cheguneh Jubran Kunim? *Ab* ((September/October, 1958): 10-17.
[35] TV Andersen, Notes on Agriculture in Iran, 24 April 1958, WBGA, 1806229.
[36] Shakry (2007: 200-201)

[37] Kambud-i Ab ra Cheguneh Jubran Kunim? *Ab* ((September/October, 1958): 10-12.
[38] Barnameh-yi Mughadamaty-i 'maliyat baray-e Tos'iyi Abyari va Sadsazy, *Ab* (September/October, 1958): 20-21.
[39] Sadsazy-i Iran, *Ab* (August/September 1955): 6.
[40] TV Andersen, Notes on Agriculture in Iran, 24 April 1958, WBGA, 1806229: 38.
[41] 'Abyari' (Irrigation). Available from: http://www.iranicaonline.org/articles/abyari-irrigation-in-iran
[42] Enclosure, FAO Report 533 Development of Land and Water Resources in Khuzestan, 1956, by AJ Bakker, Hanson (KDS) to Folk (PO), 9 January 1960, WBGA, 1806229.
[43] Also see Bagley (1976): 27; Beaumont (1974): 421.
[44] The *jurreh*, for example, was the practice of water usage extending from 8.5 to 11 minutes in length. Ghazi (1977): 74.
[45] The US Point IV program helped finance the Plan in 1950. See Bostock and Jones (1989): 112.
[46] Bostock and Jones (1989): 136.
[47] G Keep (IBRD), Iran – Diz Project, 23 August 1957, DRCP, SMLPU, Box 691, Folder 4.
[48] Barnameh-yi Mughadamaty-i 'maliat baray-e Tos'iyi Abyari va Sadsazy, *Ab* (September/October, 1958): 20.
[49] Blandford to Oliver (DRC), 21 August 1957, DRCP, SMLPU, Box 691, Folder 4.
[50] Director (Public Domain Bongah) to PO, 12 August 1957, DRCP, SMLPU, Box 691, Folder 4.
[51] Director, PO to Public Domain Bongah, 8 August 1957, DRCP, SMLPU, Box 691, Folder 4.
[52] Memorandum by W Seymour, 23 July 1959, DRCP, SMLPU: 1-7.
[53] I am grateful to the anonymous reviewer for noting that the idea of basin accounting recalls how the Bureau of Reclamation and the Corps of Engineers used a similar logic for irrigation development in the western US. Hydroelectric projects operated as 'cash register' dams to validate economically unjustifiable storage dams.
[54] Memorandum, Tolbert to Files, 1 June 1965, WBGA, 1854064.
[55] The first phase gave 'individual ownership' to former sharecropping tenant farmers. The KWPA introduced an agricultural credits system in 1962 to aid the purchase of seeds, fertilizers, insecticides, machinery, poultry, and livestock.
[56] Enclosure, DRC to Ansari, History of the Sugar Project: A Report to the Khuzestan Water and Power Authority, 1 September 1961, David E. Lilienthal Papers, SMLPU, Box 426, Folder (Re Iran 1961).
[57] Ibid.
[58] Iran-Dez Project, Merat (IBRD) to Kirpich, 1 July 1966, WBGA, 1854065; Memorandum, Merat (IBRD) to Files, 11 August 1966. WBGA, 1854065; Evans to Aldewereld (IBRD), 24 August 1966. WBGA, 1854065; Aldewereld to Knapp, 25 August 1966, WBGA, 1854065.
[59] Lilienthal to Rohani, 19 October 1966, WBGA, 1854065; Extract from notice no. 5101-DP, 15 January 1969, WBGA, 1854068.
[60] Memorandum, Tolbert to Files, 29 August 1966, WBGA, 1854065.
[61] Sicely to Evans, "Discussion of soil problems with Nederlandsche Heidemaatschappij," 29 December 1967, WBGA, 1854065.
[62] Goodman to Lejeune, 12 May 1967, WBGA, 1854065.
[63] Aldewereld to Knapp, 25 August 1966, WBGA, 1854065.
[64] Memorandum, Tolbert to Files, 29 August 1966, WBGA, 1854065.
[65] Memorandum, Merat to Files, 11 August 1966, WBGA, 1854065.

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[70] Memorandum, Risto Harma to Files, 29 March 1967, WBGA, 1854065.
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[77] Sicely (IBRD) to Coulter (Rothamsted Experimental Station), 14 March 1968, WBGA, 1854065.
[78] Warne to Creyke (IBRD), 29 August 1968, WBGA, 1854066.
[79] Cargill (IBRD) to Samii (PO), 1 August 1969, WBGA, 1854069.
[80] Ekbladh (2002b): 371; Macekura (2015): 30.
[81] Ekbladh (2002b): 371-372.
[82] Cargill (IBRD) to Samii (PO), 1 August 1969, WBGA, 1854069.
[83] On organizational work, see Bowker (1998).
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